

## CLAIMS

1. A method of grading tubules in a first image (50) of a histological slide characterised in that it has the steps of:
  - a) providing a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules,
  - b) providing a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combining data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) performing one or more of the following:
    - i) counting first objects (61) in the first image (50) which may potentially be tubules to provide a parameter *NOB*,
    - ii) counting the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter *N*,
    - iii) determining the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide parameters *RATIO*,
    - iv) determining the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter *SURF*,
    - v) determining a parameter  $PERCENT = N/NOB$ , and
    - vi) counting the number of first objects (51) containing at least medium sized holes (52) to provide a parameter *T*, and
  - e) grading the first image's tubules (51) on the basis of the one or more parameters as aforesaid with reference to parameter threshold values.
2. A method according to Claim 1 characterised in that the step of providing a second image (60) incorporates:
  - a) thresholding the first image (50) to provide a fourth image retaining relatively darker image pixels and rejecting relatively lighter image pixels,
  - b) processing the fourth image by applying the following steps in succession, the first being applied to the fourth image and each after the first being applied to the outcome of the respective immediately preceding step: inversion, morphological dilation, median filtering, hole filling and

morphological opening.

3. A method according to Claim 1 characterised in that the step of providing a third image (70) comprises thresholding the first image (50) to provide a binary fourth image in which relatively lighter image pixels have a different binary value to that of relatively darker image pixels.
4. A method according to Claim 1 characterised in that the step of combining data from the second and third images (60, 70) comprises multiplying pixels in the second image (60) by or ANDing them with respective corresponding pixels located in like positions the third image (70).
5. A method according to Claim 1 characterised in that the step of grading the first image's tubules (51) employs parameter threshold values set to obtain a grading comparable with that obtainable by an appropriate medical expert.
6. A method of grading tubules in a first image (50) of a histological slide characterised in that it has the steps of:
  - a) providing a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules and counting them to provide a parameter *NOB*,
  - b) providing a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combining data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) counting the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter *N*,
  - e) determining the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide parameters *RATIO*,
  - f) determining the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter *SURF*,
  - g) determining a parameter  $PERCENT = N/NOB$ ,
  - h) counting the number of first objects (51) containing at least medium sized

- holes (52) to provide a parameter  $T$ , and
  - i) grading the first image's tubules (51) on the basis of the first image's parameters as aforesaid with reference to parameter threshold values.
7. Computer apparatus for grading tubules in a first image (50) of a histological slide characterised in that it is programmed to:
- a) compute a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules,
  - b) compute a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combine data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) implement one or more of the following:
    - i) counting first objects (61) in the first image (50) which may potentially be tubules to provide a parameter  $NOB$ ,
    - ii) counting the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter  $N$ ,
    - iii) determining the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide parameters  $RATIO$ ,
    - iv) determining the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter  $SURF$ ,
    - v) determining a parameter  $PERCENT = N/NOB$ , and
    - vi) counting the number of first objects (51) containing at least medium sized holes (52) to provide a parameter  $T$ , and
  - e) grade the first image's tubules (51) on the basis of the one or more parameters as aforesaid with reference to parameter threshold values.
8. Computer apparatus according to Claim 7 characterised in that it is programmed to provide a second image (60) by:
- a) thresholding the first image (50) to provide a fourth image retaining relatively darker image pixels and rejecting relatively lighter image pixels,
  - b) processing the fourth image by applying the following steps in succession, the first being applied to the fourth image and each after the first being

applied to the outcome of the respective immediately preceding step: inversion, morphological dilation, median filtering, hole filling and morphological opening.

9. Computer apparatus according to Claim 7 characterised in that it is programmed to provide a third image (70) by thresholding the first image (50) to provide a binary fourth image in which relatively lighter image pixels have a different binary value to that of relatively darker image pixels.
10. Computer apparatus according to Claim 7 characterised in that it is programmed to combine data from the second and third images (60, 70) by multiplying pixels in the second image (60) by or ANDing them with respective corresponding pixels located in like positions the third image (70).
11. Computer apparatus according to Claim 7 characterised in that it is programmed to grade the first image's tubules (51) with parameter threshold values set to obtain a grading comparable with that obtainable by an appropriate medical expert.
12. Computer apparatus for grading tubules in a first image (50) of a histological slide characterised in that it is programmed to:
  - a) provide a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules and counting them to provide a parameter *NOB*,
  - b) provide a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combine data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) count the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter *N*,
  - e) determine the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide parameters *RATIO*,
  - f) determine the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter *SURF*,

- g) determine a parameter  $PERCENT = N/NOB$ ,
  - h) count the number of first objects (51) containing at least medium sized holes (52) to provide a parameter  $T$ , and
  - i) grade the first image's tubules (51) on the basis of the first image's parameters as aforesaid with reference to parameter threshold values.
13. A computer program for use in grading tubules in a first image (50) of a histological slide characterised in that it contains instructions for controlling computer apparatus to:
- a) compute a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules,
  - b) compute a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combine data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) implement one or more of the following:
    - i) counting first objects (61) in the first image (50) which may potentially be tubules to provide a parameter  $NOB$ ,
    - ii) counting the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter  $N$ ,
    - iii) determining the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide parameters  $RATIO$ ,
    - iv) determining the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter  $SURF$ ,
    - v) determining a parameter  $PERCENT = N/NOB$ , and
    - vi) counting the number of first objects (51) containing at least medium sized holes (52) to provide a parameter  $T$ , and
  - e) grade the first image's tubules (51) on the basis of the one or more parameters as aforesaid with reference to parameter threshold values.
14. A computer program according to Claim 13 characterised in that it contains instructions for provision of a second image (60) by:
- a) thresholding the first image (50) to provide a fourth image retaining relatively

- darker image pixels and rejecting relatively lighter image pixels,
- b) processing the fourth image by applying the following steps in succession, the first being applied to the fourth image and each after the first being applied to the outcome of the respective immediately preceding step: inversion, morphological dilation, median filtering, hole filling and morphological opening.
15. A computer program according to Claim 13 characterised in that it contains instructions for provision of a third image (70) by thresholding the first image (50) to provide a binary fourth image in which relatively lighter image pixels have a different binary value to that of relatively darker image pixels.
16. A computer program according to Claim 13 characterised in that it contains instructions for combining data from the second and third images (60, 70) by multiplying pixels in the second image (60) by or ANDing them with respective corresponding pixels located in like positions the third image (70).
17. A computer program according to Claim 13 characterised in that it contains instructions for grading the first image's tubules (51) with parameter threshold values set to obtain a grading comparable with that obtainable by an appropriate medical expert.
18. A computer program for grading tubules in a first image (50) of a histological slide characterised in that it contains instructions for controlling computer apparatus to:
- a) provide a second image (60) of first objects (61) in the first image (50) which are sufficiently large and of appropriate pixel value characteristics at boundaries to potentially be tubules and counting them to provide a parameter *NOB*,
  - b) provide a third image (70) of second objects (72) in the first image (50) having pixel value characteristics of fat and holes within tubules,
  - c) combine data from the second and third images (60, 70) to identify selected second objects (81) which are within first objects (61),
  - d) count the first objects (51) having selected second objects (81) within them and likely to be tubules to provide a parameter *N*,
  - e) determine the relative areas of selected second objects (81) as proportions of respective first objects (51) within which they are located to provide

parameters *RATIO*,

- f) determine the total area of selected second objects (81) as a proportion of total area of first objects (51) within which they are located to provide a parameter *SURF*,
- g) determine a parameter  $PERCENT = N/NOB$ ,
- h) count the number of first objects (51) containing at least medium sized holes (52) to provide a parameter *T*, and
- i) grade the first image's tubules (51) on the basis of the first image's parameters as aforesaid with reference to parameter threshold values.